

den. On the morning of the 22d of May he fell dead in the street from heart disease or apoplexy, it is not known which.

We have lost in him a member who, perhaps, more than any one of us, deserved to be an associate in a *Philosophical* society, and one whose philosophy, however different from that popular in this community, prompted him all his life to be an affectionate son and brother, a warm and sympathetic friend, and a man of honorable instincts.

On the Attachment of Platyceras to Palæocrinoids, and its Effects in Modifying the Form of the Shell.

By Charles R. Keyes.

(Read before the American Philosophical Society, October 19, 1888.)

Attention has lately been called to the sedentary habits of *Platyceras*,* and to the variable configuration of the apertural margin in different individuals of the same species—the confirmatory evidence being partly from analogy among living forms closely allied to the fossil; partly, and more directly, by the actual occurrence of various *Platycerata* attached to palæozoic crinoids. The association of these gasteropods with the crinoids had long been known, but prior to the recent discovery of a rich crinoidal fauna in the Keokuk rocks of Indiana illustrative examples of this kind were numerically very limited. The recorded instances of such findings have usually been accompanied by more or less brief explanatory remarks, but until 1868† the interpretations were for the most part incorrect, chiefly on account of erroneous conceptions relative to the functions of various organs in the crinoid. It was, however, noted that the molluscan shells were nearly always on the ventral side of the crinoid in the proximity of the vault opening and encompassed by the arms—a fact which was thought to afford conclusive proof of the carnivorous habits of the crinoids, which were, at the moment of perishing, in the act of devouring the mollusks. The examination of several fossil crinoids having shellfish inclosed by the arms led the Austins‡ to some general conclusions relative to the food of all the crinoids; and they give a vivid though highly imaginary account of the capture of *Producti* and univalves by the “rapacious” echinoderm. Another explanation of this phenomenon was subsequently advanced to the effect that the gasteropods were parasitic in their habits, but this also now appears to require considerable emendation. Later investigations among recent and fossil crinoideans show that the food of the species now extant consists in great part of animalcules and microscopic

* Keyes, Am. Jour. Sci., Vol. xxxvi, p. 269, 1888.

† Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1868, p. 340.

‡ Monog. Recent and Fossil Crinoidea, p. 73, 1843.

plants; that in the palæocrinoids* the mouth is subtegumentary, instead of being externally visible as in the recent crinoids, and that the aperture in the vault is the anal opening. With these considerations in view the association of these calyptræan shells and palæozoic crinoids assumes an entirely different phase from that originally entertained.

The genus *Platyceras* was founded by Conrad† in 1840 for a palæozoic group of gasteropodous shells "suboval or subglobose, with a small spire, the whorls of which are sometimes free and sometimes contiguous; the mouth generally campanulated or expanded." Hitherto these fossil shells had been referred to the genus of modern mollusca *Capulus*, proposed by Montfort‡ in 1810; or to *Pileopsis*, founded by Lamarck§ in 1822 for the same group. Conrad's name for this fossil group was not, until within the past few years, generally accepted, preference having been given by most European writers, and also by some American authors, to *Acroculia* of Phillips,|| notwithstanding the fact that the type of Phillips' genus was a typical form of *Platyceras*. Some European writers even now question the propriety of generically separating *Platyceras* from *Capulus*, and continue to describe specimens belonging to the former group under the latter genus. Among living *Calyptræidæ* it has been observed that both color and form are dependent upon individual environment and hence in forms of the same species there may be many varietal phases. It has further been noted that the majority of the members of this family attach themselves while yet quite young to stones and shells of other mollusca, and having found a suitable situation seldom, if ever, remove from the spot where first they became stationed. The character and contour of the surface on which they have settled would therefore determine to a great extent the form and outline of the apertural margin. The evidence here presented manifestly proves that the fossil representatives had, with perhaps one exception, similar habits and were subjected to like conditions of environment.

I. HISTORY.

1843. Among the first to note the intimate connection of molluscan shells and crinoids were the Austins,¶ who, in their description of *Poteriocrinites crassus*, discuss at length the "carnivorous" propensities of the crinoids in general. Particular mention is made of *Producti* being the victims of the "predatory explorations" of the *Poteriocrini*; and there is reference also to "other crinoids having been found with uni-valves inclosed within their rays, in such a position as to leave but little

*It must be borne in mind that *palæocrinoidea* and *palæozoic crinoidea* are not coextensive terms.

† Ann. Rept. Palæo. N. Y., p. 205, 1840.

‡ Conch. Syst., Vol. ii.

§ His. Nat. des Animaux sans Vertèbres, 1815-1822.

|| Palæ. Foss. Cornwall, p. 93, 1841.

¶ Monog. Recent and Fossil Crinoidea, p. 73.

doubt that a sudden death had overtaken them in the midst of their repast."

1844. De Koninck,* though possessing no specimens in which these gasteropods were associated with crinoids and probably having in mind living forms, states that in consequence of the habits which the animals of this genus (*Capulus*) have of attaching themselves to foreign bodies and remaining fixed during life, the margins of the shells become adapted to all the irregularities of the surface in contact.

1847. In America the first mention of the association of *Platyceras* and fossil crinoids was by Yandell and Shumard.† The specimen they refer to was afterwards described by the former as *Acrocrinus shumardi*. These authors seemed to have adopted the views of the Austins, and remark that they believe "the carnivorous habits of the crinoideans have been clearly made out."

1851. L. P. Yandell,‡ in a paper On the Distribution of the Crinoidea in the Western States, corroborates the statement made four years previous, and is "satisfied as to the carnivorous habits of the crinoidea." At Cincinnati he noticed several specimens of *Glyptocrinus decadactylus* Hall with gasteropods entangled in the arms. Reference is also made to a *Platycrinus* from Warsaw, Ill., and several specimens of *Actinocrinus*§ with *Platycerata* attached.

1855. Yandell|| described and figured *Acrocrinus shumardi* with a *Platyceras* attached to the vault. It is the same specimen referred to by Yandell and Shumard in 1847, and the views there expressed are here repeated.

1862. Richard Owen¶ considered that the *Platycerata* constituted the principal food of certain crinoids and therefore gave without description the name *Platyceras pabulocrinus* to a gasteropod found on *Platycrinus hemisphaericus*.

1866. In Meek and Worthen's discussion** of the genus *Platyceras* two paragraphs are devoted to the consideration of the probable habits of the species of this group. An instance is cited in which the calyptraean shell is attached to the side of a *Pentremites godoni* so as to entirely cover one of the pseudo-ambulacral fields and two of the intermediate areas, the line of contact being such as could not have resulted from accidental pressure. The improbability of the earlier views that the crinoids were in the act of devouring the gasteropods is here clearly shown.

1867. H. Trautschold†† figured and described *Capulus parasiticus* on

* Desc. des Anim. Foss. (de Belgique), p. 332, 1842-4.

† Contributions Geol. Kentucky, p. 25, 1847.

‡ Proc. Am. Asso. Adv. Sci. 1851, p. 234.

§ Actinocrinus as then used has since been subdivided into a number of genera.

|| Amer. Jour. Sci., (2), Vol. xx, p. 135.

¶ Geol. Surv. Indiana, p. 364, 1862.

** Geol. Illinois, Vol. iii, p. 384.

†† Einige Crin. und andere Thierreste des Jüngerer Bergkalks im Gouv. Moskau, p. 41, 1867.

Cromyocrinus simplex. He remarks that the gasteropod was attached to the anal plate crowded between the arms of the crinoid, and that very probably the *Capulus* was dependent for its food upon the crinoid, or perhaps fed upon the excrementitious matter. The closely allied *Cromyocrinus gemmatus* had not been found with the *Capulus* affixed.

1868. Meek and Worthen* in their notes on the Structure and Habits of the Palæozoic Crinoids refer to the attachment of *Platycerata* to two species of Crawfordsville, Ind., crinoids. Their remarks also appear in the American Journal of Science† and in the report of the Illinois Geological Survey.‡ The somewhat prolix discussion there presented, however, is directed more toward the real functions of the vault aperture in the crinoid than to the *Platyceras* itself. Special mention is made of *Platycrinus hemisphericus* Meek and Worthen and *Ollacrinus tuberosus* Lyon and Casseday from the Keokuk of Indiana. It was observed that *Platyceras infundibulum* M. & W. was usually attached to the former species, and that the anterior side of the mollusk was always directed upward, while in regard to the latter species "it is worthy of note, that it is always another, subspiral, *Platyceras* (very similar to *P. æquilaterum*) that we find attached to this crinoid, so that here, at least, it would seem that each of these two crinoids has its own particular species of *Platyceras*." It is also here shown that the contact of the gasteropod and crinoid is more than transient, as the sinuosities of the margin of the shell is adapted exactly to the irregularities of the surface of the crinoid.

1869. E. Billings§ in answering some objections urged against his views on the structure of the crinoidea, etc., supposes that when the *Platyceras* covers the ventral opening, which he regards as the mouth, there must have been space left for a stream of water to pass under the edge of the shell into the mouth of the crinoid. He adds: "The view I took of the subject in my paper was that the gasteropod ascended the stalk of the crinoid and thrust its proboscis into the mouth of the latter. The crinoid then slowly drew its arms together and held the shell fast until both died."

1879. Wetherby,|| describing some new species of crinoids from the Kaskaskia group of the Subcarboniferous, states that all of the specimens of *Pterotocrinus acutus* Weth. and *P. bifurcatus* Weth. have a gasteropod resting on the vault.

1879. H. Trautschold¶ figured and redescribed *Cromyocrinus simplex* Trauts. with a *Platyceras* attached. He suggests that the process on the anal side was built by the crinoid for protection against the parasitic mollusk, but adds that the gasteropod may have fed on the refuse matter of the crinoid.

*Proc. Acad. Nat. Sci. Phila., 1868, p. 340, *et seq.*

†2d Series, July, 1869, p. 25, *et seq.*

‡Vol. v, 1873, p. 334.

§Am. Jour. Sci. (2), Vol. xlix, p. 235.

|| Jour. Cincinnati Soc. Nat. His., Oct., 1879, p. 2.

¶Die Kalkbrüche von Mjatschkowa, p. 119, Moskau, 1879.

1881. Wachsmuth and Springer* mention a gasteropod generally covering the anal aperture of *Pterotocrinus depressus*.

1883. Julien Fraipont,† in his *Recherches sur les Crinoïdes du Famennien de Belgique*, mentions a *Capulus* affixed to a specimen of *Melocrinus globosus* Dew., and in such a position as to indicate that the *Capulus* did not form the food of the crinoid.

1885. Hinde,‡ describing a new species of crinoids with articulating spines, remarks that three out of eleven specimens discovered of *Hystriocrinus carpenteri* (= *Arthroacantha punctobranchiata* Williams) have a *Platyceras* resting on the vault, which it nearly entirely covers; and there is no doubt that the gasteropod derived its support from the materials rejected by the crinoid.

1888. Keyes,§ in the *American Journal of Science*, gives a brief summary of the sedentary habits of *Platyceras*, and mentions six species of crinoids having gasteropods attached.

II. DESCRIPTION OF SPECIMENS.

It has been intimated elsewhere that the direct paleontological evidence of the sedentary habits of the mollusca belonging to the genus *Platyceras* is found chiefly in the attachment of gasteropod shells to the calyces of certain species of palæozoic crinoids. The diverse structural differentiation of the crinoidal vault and the well-defined surface ornamentation in the various genera, presents, in those species in which the association of the univalves has been observed, determinate features for an adequate consideration of the variability in the apertural margin of the calyptræan shell. Numerous illustrative examples of the following species of crinoids have been examined: || *Ollacrinus tuberosus* Lyon and Casseday, *O. typus* Hall, *Actinocrinus verrucosus* Hall, *Physetocrinus ventricosus* Hall, *Strotocrinus regalis* Hall, *Dorycrinus immaturus*¶ Wachsmuth and Springer, *Marsupiocrinus calatus* Phillips, *Eucladocrinus millebrachiatus* Wachsmuth and Springer, *Platycrinus hemisphæricus* Meek and Worthen, *Arthroacantha punctobranchiata* Williams, *Pterotocrinus acutus* Wetherby, and *Cromyocrinus simplex* Trautschold.

In *Ollacrinus* the vault is comparatively large, nearly flat, with the anal opening eccentric, and the plates are more or less convex or nodose. In some specimens of *O. tuberosus* L. & C. from the Keokuk of Crawfordsville, Indiana, this nodosity of the ventral plates reaches a high devel-

* Revision Palæocrinoidea, pt. ii, p. 90, 1881.

† *Annals Soc. géol. de Belg.*, t. x, Mémoires, 1883, p. 62.

‡ *Annals and Mag. Nat. His.*, March, 1885, p. 172.

§ *Am. Jour. Sci.* (3), Vol. xxxvi, p. 269, 1888.

|| The observations herein noted are based principally upon numerous exemplifications in the extensive and unrivaled series of paleozoic crinoids in the collection of Messrs. Wachsmuth and Springer, to whom sincere thanks are tendered for free access to their cabinets.

¶ It may be stated that this species has been figured and described in the eighth volume of the *Illinois Geological Survey*, now in press.

opment. The nodes of certain plates are much more pronounced than others, and are more or less confluent, forming a conspicuous stellate figure, the points of which are directed interradially. More than one-half of the Crawfordsville specimens of this species have resting on the vault a *Platyceras*—usually *P. æquilaterum* Hall. The specimens illustrate well the adaptation of the apertural margin of the shell to the irregularities of the crinoidal surface, for it is clearly observable, as was first pointed out by Meek and Worthen, that the contact of the gasteropod shell and crinoid is not the result of accidental pressure, but that the mollusk adhered to the surface of the crinoid for a considerable period, as is shown by the sinuosities of the peristome corresponding exactly to the inequalities of the surface beneath. In young shells the sinuosities of the apertural margin are comparatively much more pronounced than in older individuals. Many of the latter exhibit much irregularity in the lines of growth, which might at first appear to be due to a change of situation, but closer inspection shows that this is not the case. When the plates of the vault are nodose, as in *Ollacrinus tuberosus*, the lines of growth in old shells, contrary to the more usual manner among gasteropoda generally, are far from being even approximately parallel to one another; and in the margin of the shell a sinus caused by a nodose plate at one period of growth may be represented in the next by a projecting lobe which had extended into a deep depression between the nodes of two contiguous plates. From an examination of the impressions made by the calyptræan shell on the vaults of *Strotocrinus* and some other genera, it appears that the anterior end of the *Platyceras* is always stationary at the margin of the anal opening, and that as the growth of the shell continues the posterior portion is removed farther and farther from the ventral aperture in the crinoid. *Platyceras æquilaterum*, when stationed on the flat vault of *Ollacrinus*, has the spire much more depressed, and the aperture comparatively much larger than is usual with this species. This fact is also in accordance with observations among the living representatives of a closely allied genus, *Capulus*, in which it has been found that individuals attached to flat surfaces have the shells much more depressed than those that have settled on convex bodies. If *Platyceras æquilaterum* was entirely sedentary in its habits, as there is reason to believe, it would seem, from the diverse forms, that its habitat comprised a variety of objects other than crinoids. Indeed the shell of this gasteropod is extremely variable in form, some specimens being nearly hemispherical with a small spire subcentrally located, while others are nearly flat and the spire projects far beyond the posterior margin of the aperture. Of the many examples of crinoids with attached *Platycerata* only two instances have been noted in which these gasteropods are associated with *Actinocrinus*, or other genera having a prolonged anal tube—the so-called “proboscis.” Meek and Worthen* knew not a single case of this kind, and state that it is “probably due to the fact that in species with a ‘proboscis’ there is much less

* Geol. Ill., Vol. v, p. 335.

room for attachment to the vault." If the gasteropods of this genus subsisted upon the excrementitious matter from the crinoid the reason is obvious for their non-occurrence on species having a prolonged anal tube. In one of the cases referred to the *Platyceras* was just visible between two of the arms of the crinoid, but the matrix was too compact to permit of removal, and in the other, *A. verrucosus* Hall, the molluscan shell was at the base of the anal tube, which, however, appeared to have been injured. It is very probable that on account of this deformity there was an additional opening at its base.

But few illustrative instances are furnished by *Physetocrinus*. In *P. ventricosus* Hall the dome is low, hemispherical, but the univalve associated is remarkable for its comparatively large size, covering nearly the entire vault. *Strotocrinus* presents numerous interesting examples. *S. regalis* Hall, from the Burlington limestone, has the vault relatively very large and flat as in *Ollacrinus*, but the dome plates are small and nearly plane. Like in the *Ollacrinus* from Crawfordsville, Ind., the undetermined *Platyceras* found on this crinoid is very much depressed, the aperture ample and nearly circular in outline. In several specimens the univalve has been carefully removed, revealing a series of concentric impressions which, as has been previously stated, mark the different stages in the growth of the shell. Perhaps one of the most notable examples is an undescribed *Dorycrinus** from the Kinderhook of Marshall county, Iowa. In this species the dome is convex with broad radial elevations which become more pronounced toward the arm bases. On the posterior side of the calyx there is a prominent ridge, at the top of which is situated the anal opening, just below the central dome plate—the latter being rather large and produced into a high conspicuous node. The arms are twenty in number, equally divided among the rays, and equidistant from each other, forming a close, almost continuous circle around the periphery of the vault. The associated *Platyceras* is of the *P. infundibulum* type, but instead of being attached laterally between the two posterior arms—as in the case of the Crawfordsville species of *Platycrinus*—it is stationed directly on the vault, with the anterior portion of the shell over the anal opening. In this position the mollusk has its anterior extremity directed toward the posterior side of the crinoid, instead of the usual opposite direction; it also covers the subspinous process of the central plate, and the apertural margin reaches to the arm bases on all sides except the two postero-lateral. When thus covering nearly the entire vault the depressed interradiial areas give to the aperture of the shell a marked quinquelobate appearance.

The Platycrinidæ present both numerically and structurally the finest series of illustrative examples, but they are unequally distributed among three genera: *Marsupiocrinus*, *Eucladocrinus* and *Platycrinus*—the typical genus furnishing the large majority of the specimens. In *Marsupiocrinus*

*This *Dorycrinus* has been defined by Wachsmuth and Springer, in the eighth volume of the Illinois Geological Survey, now in press.

caelatus Phillips, from the Upper Silurian of Dudley, England, the vault is composed of a large number of small plates, and the anus is subcentral. In *Platycrinus* and *Eucladocrinus* the vault is more or less hemispherical with the simple anal aperture lateral in position. *Platycrinus hemisphaericus* M. and W. is a common species in the Keokuk shales of Crawfordsville, Indiana, and like *Ollacrinus* from the same locality a large proportion of the specimens have attached *Platycerata*—usually *P. infundibulum* M. and W., though not unfrequently *P. equilaterum* Hall is also found associated with this *Platycrinus*. The former is a straight, elongate-conical shell with numerous longitudinal plications; while the latter is a more or less depressed, subspiral form, with a very large aperture. The attachment of these gasteropods to *Platycrinus* is somewhat different from that of the other genera mentioned, being at the side between the arms, instead of on the vault. As the growing shell increased in size it encompassed the bases of two postero lateral arms, and in some cases the posterior portions of the univalve even extended to and enclosed the stem of the crinoid. *Eucladocrinus*, from the Burlington limestone, presents the same general features as *Platycrinus* in the attachment of *Platycerata*; and it is worthy of note that this gasteropod from the Burlington is remarkably similar to *P. infundibulum* from the Keokuk. In *Arthroacantha*, *Platyceras erectum* Hall is found on the vault. Hinde* mentions two species of *Platyceras* associated with this crinoid, *P. erectum* Hall and *P. dumosum* Conrad. In *Pterotocrinus* the vault is entirely different from those of the other genera here mentioned. It is much elevated, being two or three times as high as the dorsal cup. The first radial dome plates are produced into monstrous alate processes, leaving a small summit which is perforated for the anus. The anal opening is usually covered by a very small *Platyceras*. In a number of examples the summit of this crinoid became too small for this little gasteropod, and the margin of the growing shell has followed closely the depressions between the radial dome plates, which have given rise to large deep sinuosities in the apertural margin.

Cromyocrinus simplex Trauts., from the subcarboniferous of Russia, supports a broad subspiral *Platyceras* described as *Capulus parasiticus* Trauts. Trautschold† in describing the crinoid calls attention to a cylindrical process lying above the anal plate, and to a gasteropod frequently found attached to this region of the calyx, he then adds: "Es ist nicht unmöglich, dass der oben beschriebene cylindrische Processus der Analplatten zum Schutz gegen diese Verfolger des *Cr. simplex* aufgebaut ist." The "cylindrical process" here referred to is manifestly a ventral sac, and both its structural and functional character were entirely misunderstood.

The occurrence of *Platycerata* attached to some other species of crinoids has been noticed, but opportunity for personal examination has not been offered. Yandell‡ mentions that gasteropods are sometimes enclosed in

* Ann. and Mag. Nat. Hist., March, 1885, p. 172.

† Die Kalkbrüche von Mjatschkowa, p. 119.

‡ Proc. A. A. A. S., 1851, p. 234.

the arms of *Glyptocrinus decadactylus* Hall. This writer in his description* of *Acrocrinus shumardi* also calls attention to a *Capulus* on the vault of that species as clearly proving the carnivorous habits of the crinoid-eans. *Melocrinus globosus* Dewalque, with a *Platyceras* adhering, has been found in the schistes de Frasnes à Senzeille by Fraipont,† who says: "Cette position du mollusque sur de crinoïde vient apporter une preuve de plus contre l'opinion des paléontologues qui soutiennent que les *Capulus* rencontrés sur ces crinoïdes servaient de nourriture à ceux-ci." Finally, Meek and Worthen‡ mention a *Platyceras* adhering to the side of a *Pentremites godoni* "so as to cover one of the pseudo-ambulacral fields and two intermediate areas "

III. SUMMARY.

When attention was first directed to fossil crinoids having *Platycerata* attached, conclusive proof of their carnivorous habits was thought to be established, and inasmuch as it was then considered that the aperture in the vault was the mouth, this explanation for a long time appeared very plausible. Consequently the conclusion was very naturally reached, that the crinoid when it perished was in the act of devouring the mollusk. Meek and Worthen§ seem to have been the first to demonstrate that the prevalent opinions regarding the intimate association of crinoid and *Platyceras* were erroneous, and that the gasteropod was undoubtedly stationed on the crinoid for a protracted period, and very probably even for the greater portion of its life. But notwithstanding the fact that the univalve was almost invariably situated over the ventral aperture, and that this opening was recognized as the anus, these writers do not appear to have entertained for a moment the idea that the gasteropod may have been nourished on the refuse matter from the crinoid. The latter view was more recently advanced by Wachsmuth, and has since been favorably received by other paleontologists. In all of the specimens lately examined—probably upwards of one hundred and fifty—the *Platyceras* covers the anal opening of the crinoid, and as far as observable, it is always the anterior portion of the molluscan shell that is directed towards the vault aperture. In those examples in which the shell has been removed, its impression made on the ventral surface shows that the anterior margin of the peristome was at the edge of the opening in the dome—a position that would have brought the mouth of the mollusk directly over the anal aperture of the crinoid. The food of recent crinoids consists chiefly of animalcules and microscopic plants, and the living Calyptræidæ subsist on food of a similar nature. From analogy it might be inferred that the food of the fossil crinoids and mollusks must have been like that of their recent representatives. So far as these echinoderms are concerned, there appears

* Am. Jour. Sci., (2), Vol. xx, p. 135.

† Annal Soc. géol. de Belgique, t. x, Mémoires, 1883, p. 62.

‡ Geol. Ill., Vol. iii, p. 386.

§ Proc. Acad. Nat. Sci. Phila., 1868, p. 340, et seq.

to be no serious objections to this inference; but with the univalves their position through life indicates that their food was in great part at least of an entirely different nature, and this is one of the considerations that suggest a possibly much wider generic separation of *Platyceras* and *Capulus* than is apparent from a comparison of the shells. The anatomy of the crinoid and the position of the molluscan shell are opposed to the supposition that the gasteropod may in any way have been nourished on the food of the crinoid. This would imply that the mollusk was parasitic in its habits, a view which, though held by some writers, does not appear to be structurally sustained. While no doubt the *Platyceras* derived the greater portion of its food from excrementitious matter, nourishment from other sources may also have been obtained, and in all probability it was very similar to that of the crinoids and living Calyptræidæ. Furthermore there does not seem to be the slightest indication that the crinoid was in any manner inconvenienced by the attachment of the gasteropod, except perhaps in a few cases where the molluscan shell has encircled the posterolateral arms which were in consequence slightly pressed outward. The only really noticeable effect of the presence of *Platyceras* on the crinoid is a comparatively shallow depression or groove on some of the vault plates—marking the position of the shell margin; yet in the majority of specimens this feature is scarcely perceptible.

In considering the structural peculiarities of the *Platyceras* shell three features—the general form, the configuration of the aperture, and the surface markings—appear to have been susceptible of considerable modification as the result of the sedentary habits of the mollusk. An examination of a large series of certain species of *Platyceras* reveals that the variant tendency in all three of these particulars is much greater than might be supposed, but when the attachment of these gasteropods to foreign bodies is taken into consideration the causes for such varietal development become manifest. It has been shown that the mollusk doubtless remained fixed throughout a greater portion of life, and that the surface upon which it first settled determined in great part both the form of the shell and the shape of its aperture. When the surface of attachment was flat, as in the vaults of *Ollacrinus* and *Strotocrinus*, the shell was greatly depressed and the peristome ample, but when the foreign body was strongly convex the shell was more conical with a comparatively much smaller aperture. It has been shown elsewhere that, in regard to the second of the three variant features observable in the calyptræan shell, the margin of the peristome partakes of all the inequalities of the surface to which the gasteropod adheres. Few of the species attached to crinoids may be said to have true surface ornamentation, but the longitudinal folds or plications in the shell are in many cases due largely to the character of the surface of attachment. In some specimens of *Platyceras infundibulum* M. and W. there has been observed in addition to the undefined longitudinal folds, series of small conspicuous nodes; but in all examples these nodes appear to have resulted from the peculiar nodose ornamentation of *Platycrinus hemisphaericus* with which these univalves were associated.

Recapitulating the salient features relative to *Platyceras* as here presented, it appears : (1) that many, if not all, of the *Platycerata* were stationary during life ; (2) that the nourishment of these gasteropods was derived in great part at least from the excrementitious matter of the crinoid ; and (3) that the form of the peristome and its marginal configuration, being dependent upon the surface of attachment, have small value as characters for specific distinction. The first and third of these propositions are consonant with observations made upon living Calyptræidæ, while the second does not seem to present in this group any living analogue, and this fact is indicative of perhaps a wider separation generically of *Platyceras* and *Cupulus* than has hitherto been considered.

The species of *Platyceras* in which sedentary habits are positively known from the attachment of the gasteropods to foreign bodies, are :

<i>Platyceras æquilaterum</i> Hall,	<i>P. infundibulum</i> M. and W.
<i>P. parasiticum</i> (Trautschold),	<i>P. chesterense</i> M. and W.
<i>P. erectum</i> Hall,	<i>P. dumosum</i> Conrad,
<i>P. formosum</i> Keyes, and five undetermined species.	

IV. DESCRIPTIONS OF FOUR NEW SPECIES OF PLATYCERAS FROM THE LOWER SUBCARBONIFEROUS OF IOWA.

Platyceras capax, nov. sp. (Plate, figs. 14 and 15).

Shell below medium size, ovate, subspiral, forming scarcely one volution, rapidly and regularly expanding, both transversely and in the opposite direction, to the aperture. Apex small, obtuse, free, but more or less incurved toward the body of the shell, which is strongly arcuate ; very slightly deflected dextrally. Aperture nearly circular in outline, margin attenuated, and but slightly sinuous. Surface marked by distinct often somewhat imbricated lines of growth.

Horizon and locality. Burlington limestone near Burlington, Iowa.

This species approaches, nearer than any other, some forms of *P. æquilaterum* of Hall from the Keokuk limestone, but differs in having the body of the shell more arcuate and in uniformly expanding much more rapidly in the direction of the longitudinal diameter of the aperture. The apex is also farther removed from the body of the shell than in the Keokuk species, and there is no indication of longitudinal folds.

Platyceras obliquum, nov. sp. (Plate, figs. 12 and 13).

Shell of medium size, irregularly oblong, subspiral, forming one volution, regularly enlarging, slightly more rapidly transversely than in the opposite direction, to the aperture. Apex large, obtuse, far removed from the body of the shell, which is broadly arched ; very noticeably oblique to the plane of general curvature in the body of the shell. Aperture irregularly quadrangular in outline ; lip sharp, and more or less sinuous. Surface marked by several undefined longitudinal plications, which sometimes form longitudinal series of obscure nodes ; these are crossed by numerous sinuous often subimbricated lines of growth.

Horizon and locality. Limestones of the Upper Burlington at Burlington, Iowa.

Platyceras latum, sp. nov. (Plate, figs. 10 and 11).

Shell large, depressed, forming about one and one-half volutions, very rapidly expanding from the apex to the aperture, but enlarging transversely much more than in the opposite direction; posterior side comparatively very short. Apex small, incurved, but free from the body of the shell, and nearly in the same plane as the general curvature. Aperture very large, campanulate, transversely elliptic; lip attenuated and slightly sinuous. Surface marked toward the aperture by a few small nearly obsolete folds, and by numerous sinuous lines of growth.

Horizon and locality. Burlington limestone at Burlington, Iowa.

Platyceras formosum, nov. sp. (Plate, figs. 8 and 9).

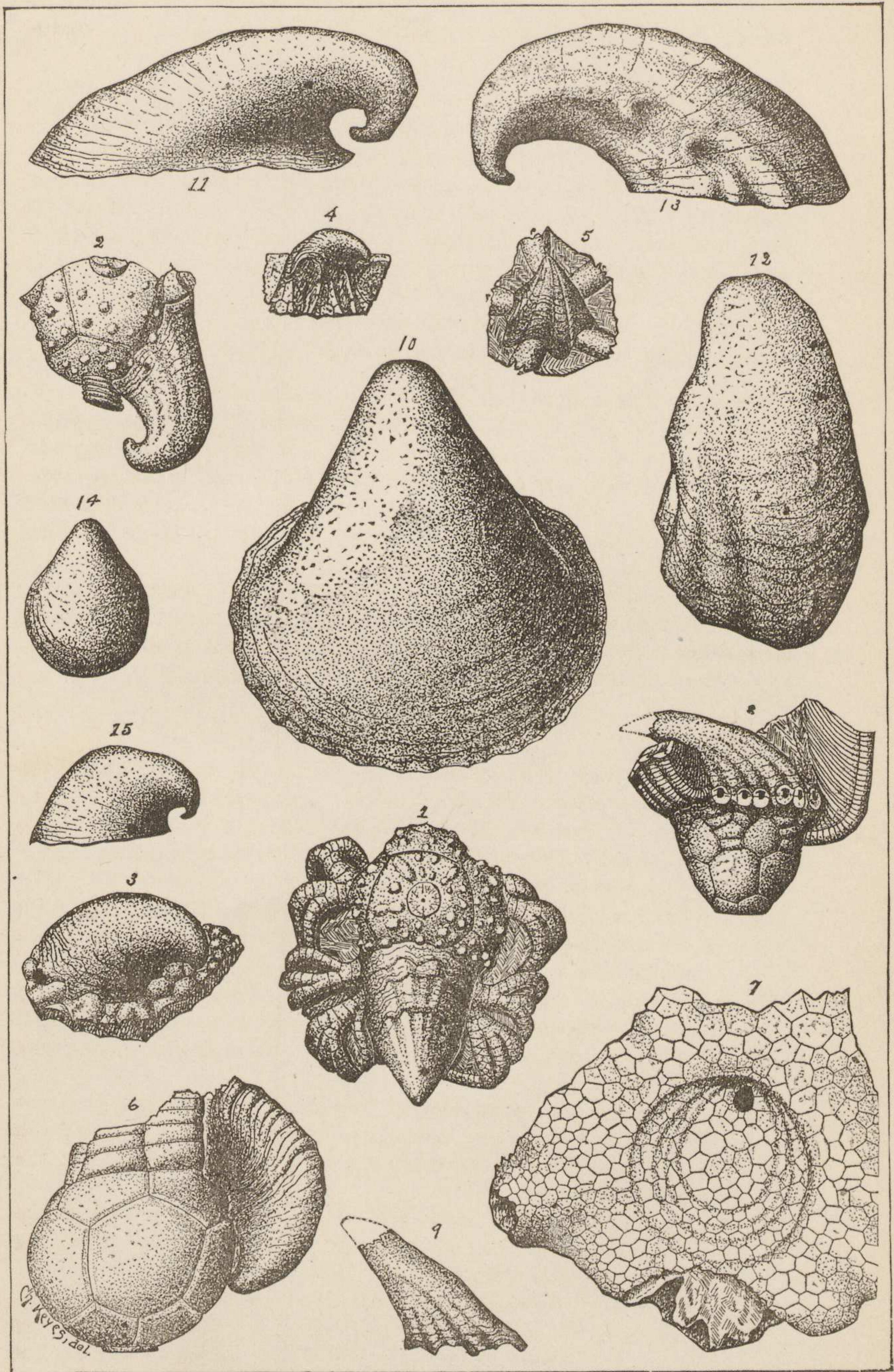
Shell curved, slightly oblique, enlarging rather rapidly to the ample irregularly pentalobate aperture, posterior side rather short and concave, lateral slopes nearly straight. Apex apparently obtuse. Aperture rather large, somewhat pentalobate. Surface marked by five broad well-defined longitudinal plications, each of which are composed of several smaller folds; these are crossed by sinuous lines of growth.

Horizon and locality. Kinderhook beds of Marshall county, Iowa.

The two specimens of this species found are both attached to the vaults of specimens of a *Dorycrinus* which has been described in the forthcoming volume of the Illinois Geological Survey now in press.

EXPLANATION OF PLATE.

- Fig. 1.—Dorsal view of *Platycrinus hemisphaericus* M. and W. with *Platyceras infundibulum* M. and W. attached to anal side.
- Fig. 2.—Lateral view of *Platycrinus hemisphaericus* M. and W. with *Platyceras equilaterum* Hall attached to the anal side, partly enclosing the postero-lateral arms and the stem.
- Fig. 3.—Portion of the vault (viewed obliquely) of *Ollacrinus tuberosus* Lyon and Casseday with *Platyceras equilaterum* Hall covering the anal aperture.
- Fig. 4.—Portion of the vault of *Pterotocrinus acutus* Wetherby with *Platyceras chesterense* M. and W. attached and covering the anal opening. *r, r*, the fractured surfaces of the monstrous alate radial dome plates.
- Fig. 5.—Portion of the vault (viewed from above) of *Pterotocrinus acutus* Weth. with *Platyceras chesterense* attached; another specimen showing the five prominent folds in the gasteropod shell. *r, r*, the radial dome plates.
- Fig. 6.—Lateral view of *Cromyocrinus simplex* Trautschold with *Platyceras parasiticum* (Trauts.) attached to the anal side. From the Subcarboniferous of Russia.
- Fig. 7.—Portion of the vault of *Strotocrinus regalis* Hall with the *Platyceras* removed, showing the anal aperture of the crinoid and the concentric impressions made by the lip of the gasteropod shell at different periods, which mark the growth of the shell.



Keyes on *Platycephalus*.